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Filter element

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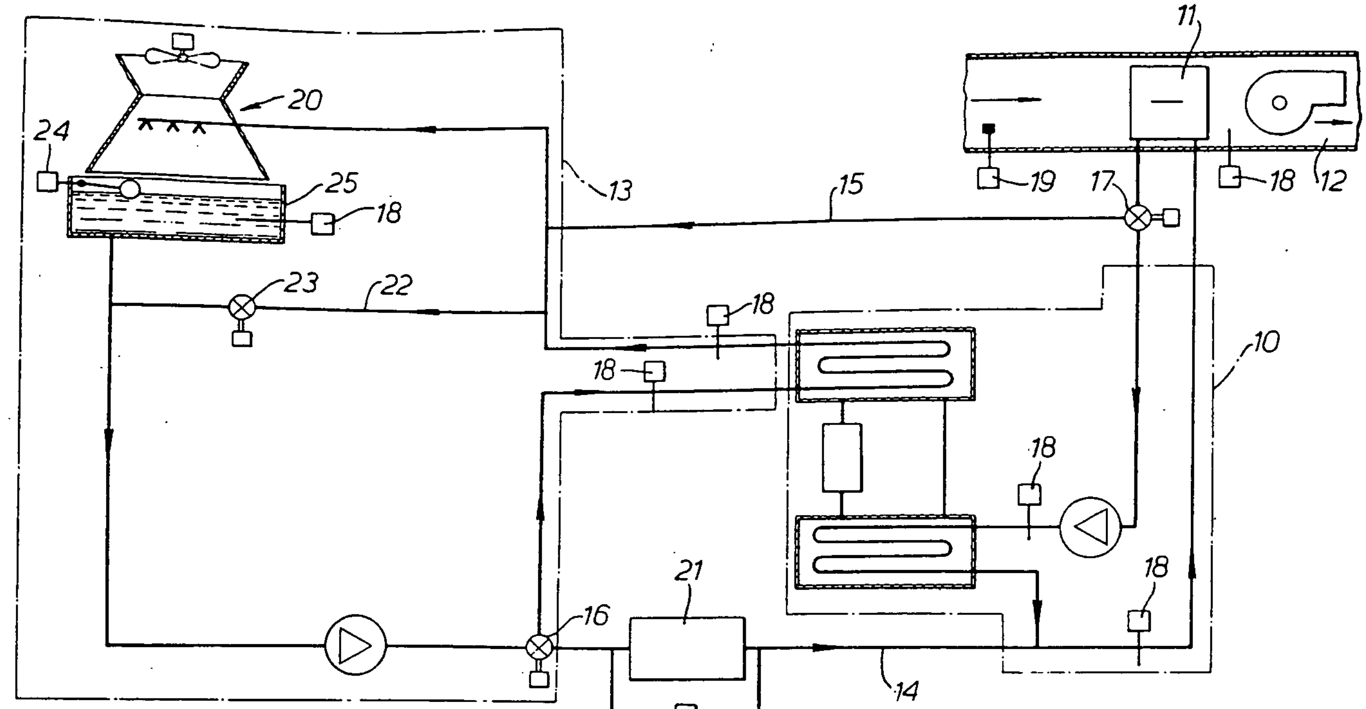

FIG. 1.

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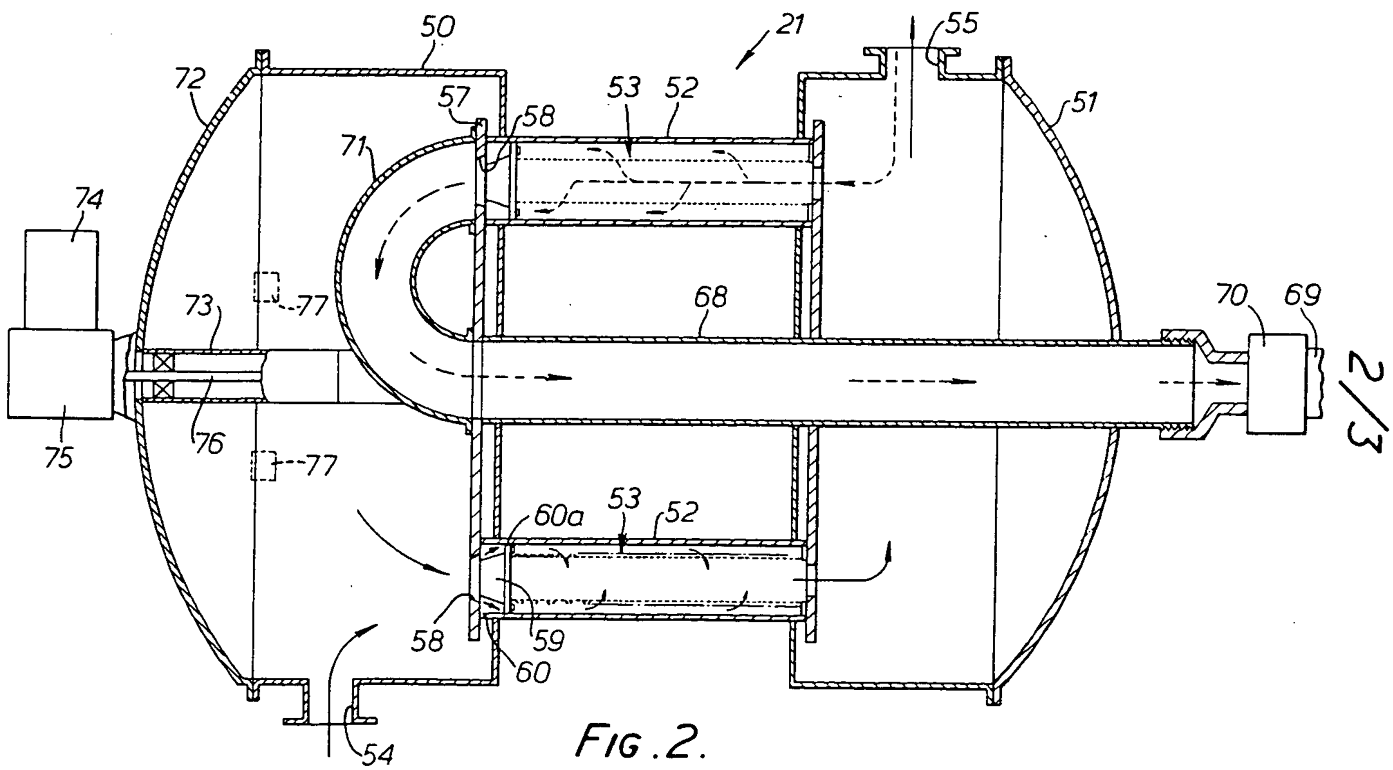

FIG. 2.

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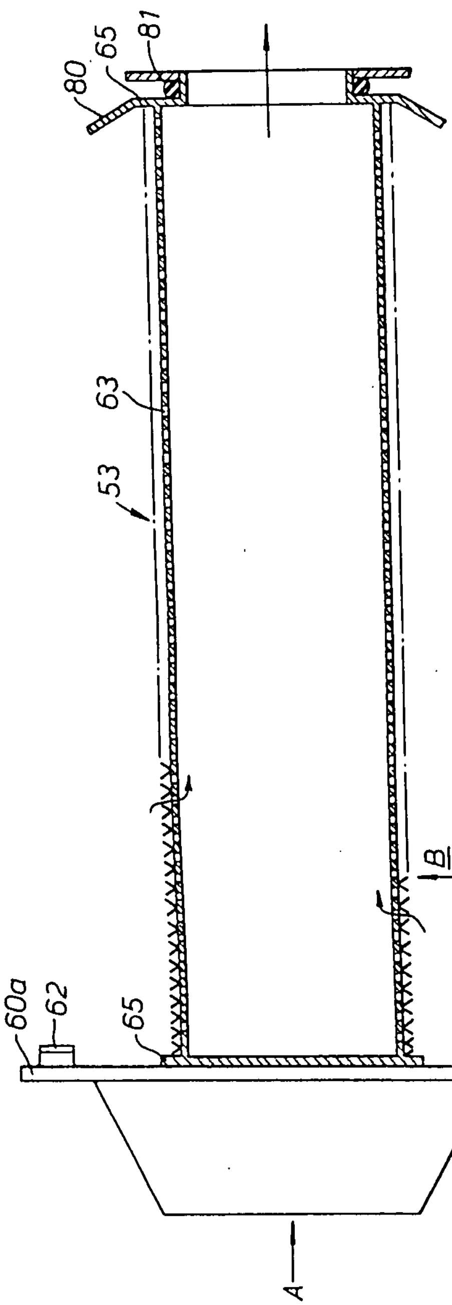

Fig. 3.

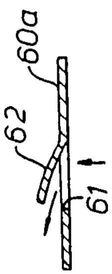

Fig. 5.

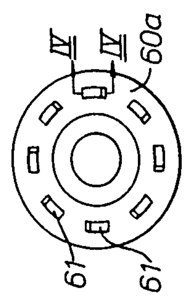

Fig. 4.

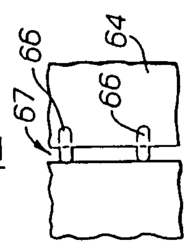

Fig. 6.

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Filter Element

This invention relates to a filter element and air conditioning apparatus including that element.

In many known air conditioning systems there is a main cooling circuit in which water chilled by a refrigerator passes through one or more heat exchangers. Additionally there is often a further circuit for cooling the refrigerator which includes an air cooling tower on the roof of the building. Refrigerators are known to consume well over 50% of the total energy requirements of such air conditioning systems. It has therefore been proposed to connect the air cooling tower across the heat exchanger, whilst isolating the refrigerator, whenever the external temperature falls below a known level. Although such a system does provide a reduction in energy consumption and therefore, running costs, the energy consumption of such systems is still excessive. In addition the known system introduces a number of problems in relation to filtering the cooled liquid.

The invention consists in a backwash filter element for filtering liquids flowing in a first direction, comprising a spring having a plurality of convolutions having adjacent parts defining filter gaps therebetween, spacer means formed on the spring for defining the minimum gap between the parts and means for holding the spring in compression, the

adjacent parts defining divergent channel means extending from the gaps in the first direction for directing liquid, flowing in a second opposite direction, against the parts in a sense to force the parts apart to increase the size of the gaps. The spring, or at least a part thereof, may be generally V-shaped in cross-section, in which case the V-sections may be directed generally in the first direction of flow. Alternatively the spring, or at least a part thereof, may be diamond shaped in cross-section.

The spring may be mounted on a perforated cylinder and means may be provided for allowing manual partial release of the components for cleaning.

The invention can be performed in a number of ways, specific embodiments of which, with modifications, will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic plan of an air conditioning apparatus in which the filter element of the invention may be used;

Figure 2 is a part cut away side view of a filter for use in the apparatus of Figure 1;

Figure 3 is an enlarged part sectional view of a filter element for use in the filter of Figure 2;

Figure 4 is an end view of the filter element, when viewed on the arrow A, but on a reduced scale;

Figure 5 is an enlarged scrap section taken along the line IV-IV in Figure 4; and

Figure 6 is an enlarged scrap view on the arrow B in Figure 3.

The air conditioning apparatus shown in Figure 1 broadly comprises a chiller or refrigerator generally indicated at 10, a heat exchanger 11 connected across the outputs of the chiller 10 and disposed in an air duct 12, and and air tower cooling circuit generally indicated at 13 for cooling the chiller 10 and connectable by pipes 14 and 15 and valves 16 and 17 to supply cooling liquid to the heat exchanger 11.

A number of temperature detectors 18 are disposed throughout the system to supply temperature readouts to a microprocessor control system (not shown). An enthalpy detector 19 is located in the air duct 12, which is for the purpose of this description the main air intake duct

for the building being served by the apparatus. The output of the enthalpy detector is also fed to the control system.

The control system is arranged to operate the apparatus in one of three modes, in accordance with the inputs to the system. In the first mode valves 16 and 17 are adjusted to connect the chiller 10 alone across the heat exchanger 11; circuit 13 merely serving to cool the chiller. In the second mode the air cooling tower circuit 13 alone is converted to the heat exchanger 11 and the chiller is isolated and switched off. In the third mode valves 16 and 17 are arranged to allow a proportion of the liquid from the air cooling tower circuit 13 to flow through the heat exchanger 11, whilst simultaneously permitting operation of the chiller.

The mode selected by the control system depends on a number of factors such as the enthalpy, or alternatively the wet bulb temperature, of the air entering the duct 12, the temperature of the cooling liquid in the circuit 13, including the temperature of the return flow liquid, the temperature existing in the building (a measure of which can be obtained by monitoring the enthalpy of the output air from the building), the temperature desired in the building or parts thereof and the economic operating ranges of the particular equipment in use.For any set of conditions the control system is programmed to operate the apparatus for minimum energy consumption commensurate with maintaining the desired psychometric conditions within the building.

The control system may also be arranged to control the chiller so that the temperature of the chill liquid leaving the chiller varies inversely with the external environmental temperature in such a way as to maintain the highest possible chill water temperature which can result in the desired air temperature in duct 12.

As the chiller 10 is responsible for the major proportion of the energy consumption of the system, it will be appreciated that the use of the apparatus in the third mode will reduce the energy costs of the apparatus as it makes it possible to obtain partial cooling of the cooling liquid by passing it through the air cooling tower 20 before the environmental temperature has dropped sufficiently for the tower to cool all the liquid.

When the apparatus is operated in its second or third modes liquid, which has passed through the air cooling tower 20,is fed through the refrigerator 10 and/or the heat exchanger 11. Such water is often contaminated and it is necessary to filter this water for example by the strainer or filter 21 in pipe 14. Alternatively the filter may be placed in circuit 13 downstream of the cooling tower 20. In this position it also serves to clean the cooling tower circuit liquid during the first mode of operation preventing a big build up of contamination. Details of filter 21 will be discussed below.

A bypass 22 is provided in cooling tower circuit 13 to allow the temperature of the liquid in this circuit to

be controlled by mixing in uncooled liquid. A valve 23 in this line is controlled by the control system.

Preferably the filter 21, valves 16 and 17 and the control system are assembled in a modular unit, which can be incorporated into an existing chiller system having an air cooling tower. The module may also include operating parameter displays and alarm circuits for giving audible and/or visual signals when safe levels are exceeded by one or more operating parameters.

As the filter 21 will become progressively contaminated it is desirable to use a filter, which can be back washed without interrupting the normal function of the system. Typically such filters include an array of filter elements, which can be back washed singly or in pairs, whenever the pressure difference across them exceeds a given value. A suitable detector is shown at 21a.

The output of the detector can be fed to the control system and back washing can be superintended by the control system. This is important because in existing systems if the back washing is ineffective, as can occur if water is heavily contaminated, the back washing cycle can continue indefinitely draining down the whole system. In the apparatus of Figure 1 a level detector 24 is provided in the reservoir 25 of the cooling tower 20. This detector enables the lost liquid to be replenished and further can provide an 'override back wash' signal to the control system

to prevent excessive draining of the system.

In cases where the user's water supply is metered it can be economic to drain the back wash water into a tank from where it can be cleaned and recirculated into reservoir 25 on demand. Further a heat exchanger can be incorporated into the tank to provide another source of cold, or alternatively a heat source for other purposes, depending on the operating conditions at back wash.

Figure 2 shows one example of a suitable filter 21 for use in the system. The filter comprises an inlet header 50, an outlet header 51 and interconnecting filter tubes 52, arranged in a circular array. Each filter tube 52 contains a generally cylindrical element 53. In normal operation fluid flows (as shown in solid line) from an inlet 54 in header 50 into tubes 52, through the walls of elements 53, from outside to inside, into the outlet header 51 to outlet 55.

The inlet end of each tube 52 engages a seal plate 57 around respective frusto-conical apertures 58. The apertures 58, together with restrictors 59 mounted on the ends of the filter elements 53, define an annular divergent inlet passage 60 to take the flow of fluid to the peripheries of the elements 53.

Each restrictor 59 is generally frusto-conical and has an annular peripheral flange 60a around its larger

(downstream) end. The flange 60a (as can best be seen in Figures 3 to 5) is formed with slots 61 spaced in an annulus around the flange and having upstanding guide elements 62 on their downstream side for imparting a swirl to the fluid flowing through the slots 61. The swirling of the fluid causes it to be pushed along the length of the filter element 53 to provide a generally even flow distribution over the length of the element 53.

Referring to Figure 3 each element 53 comprises a perforated hollow cylinder 63 on which is mounted a helical spring 64. The spring 64 is V-shaped in cross-section and is held in compression between end flanges 65 on the cylinder 63, such that the adjacent portions of the spring are urged together. As can be seen in Figure 6 the spring 64 is formed with spaced lateral indentations 66, which engage the adjacent portion of the spring, when it is compressed, and hence define a filter gap 67 of known dimensions (say 1/5000th inch).

When fluid flows in the solid line direction, the pressure of the fluid acts in a sense to open the arms holding the spring in its filtering mode. As filtering progresses particles will become trapped in the gaps 67 causing a pressure drop across the gaps causing detector 21a to initiate back wash. In this mode the fluid flows in the opposite direction, and acts on the opposite side of the V's i.e. in a sense to close them. This results

in the size of the gaps 67 being increased and the trapped particules are released. In an alternative embodiment the spring may have a diamond cross-section.

To enable the elements to be back washed a discharged tube 68 is provided. The tube 68 extends axially from a central aperture in the seal plate 57, through outlet header 51, to a drain 69, via a control valve 70. A U-shaped connecting pipe 71 is mounted for rotation about the axis of the tube 68 and is slidingly and sealingly engaged at each end on the seal plate 57, such that as it rotates it successively connects the apertures 58 to the tube 68, causing a pressure reversal in the filter tubes 52 and hence causing the elements in the tubes to be back washed.

The pipe 71 is mounted for rotation on a hinged door 72 of inlet header 50 by a cylindrical casing 73. A

motor 74 is mounted on the door 72 by a gear box 75, which is coupled to the pipe 71 by a drive 76, which is enclosed by the casing 73. When the detector 21a detects a 'back wash' condition it causes a single cycle of the motor 75, and hence of the pipe 71, and opens the valve 70. At the end of a cycle the outer end of the pipe 71 engages the plate 57 in a rest position between two apertures 58, so that all the tubes 52 are available for filtering.

The door 72 is hinged, at 77, such that the pipe 71 and the casing 73 can be swung right out of the header 50. The plate 57 is quick releasably mounted on the header so that it to can be removed allowing ready access to the filter elements 53. Preferably one flange 65 is movable outwardly axially to allow partial release of the spring 64 to easy cleaning of the filter element. In any case causing the fluid to flow from outside to inside, which is the reverse of the normal configuration, greatly reduces the cleaning time required.

In some cases it may be desirable to increase the number of tubes 52, by having inner and outer arrays; in which case two back wash coupling pipes may be provided.

It will be appreciated that the inlet 54 may be located tangentially of the header 50, causing the incoming liquid to flow in a vortex. This vortex may

introduce sufficient swirl into the flow into the filter tubes 52 to allow the flange 60a to be omitted. Indeed, catch plates (not shown) may be attached to the header wall to collect large particles thrown to the outside of the vortex. The flange 65 may be enlarged and bent up at 80 to define an annular cup, which will serve to clear debris from the tube 52, when the filter element 53 is removed for cleaning. The element 53 may be resiliently held in the tube 52 by a compressible ring 81.

At least part of the above element and apparatus is described and claimed in our copending Divisional Application No. 8419888.

CLAIMS

1. A backwash filter element for filtering liquids flowing in a first direction, comprising a spring having a plurality of convolutions having adjacent parts defining filter gaps therebetween, spacer means formed on the spring for defining the minimum gap between the parts and means for holding the spring in compression, the adjacent parts defining divergent channel means extending from the gaps in the first direction for directing liquid, flowing in a second opposite direction, against the parts in a sense to force the parts apart to increase the size of the gaps.

2. An element as claimed in Claim 1 wherein the spring, or at least a part thereof, is generally V-shaped in cross-section.

3. An element as claimed in Claim 2, wherein the V-sections are directed generally in the first direction of flow.

4. An element as claimed in Claim 1 wherein the spring, or at least a part thereof, is diamond shaped in cross-section.

5. An element as claimed in any one of the preceding Claims wherein the spring is mounted on a perforated cylinder.

6. An element as claimed in any one of the preceding claims including means for allowing manual partial release of the spring for cleaning.

7. A filter element substantially as hereinbefore described with reference to Figures 3 to 6 of the accompanying drawings.

8. A modular unit for converting the mode of operation of an existing air conditioning system incorporating refrigerating means, a heat exchanger and an external cooling tower, the unit including a filter incorporating a filter element as claimed in any one of claims 1 to 11, connectable downstream of the cooling tower and control means for connecting the air cooling tower, via the filter, across the heat exchanger.

9. A unit as claimed in claim 8, wherein the control means includes a plurality of fluid valves.

10. A unit as claimed in claim 8 or 9, wherein the control means further includes a microprocessor for controlling the operation of the valves and/or the filter.

11. A unit as claimed in any one of claims 8 to 12, wherein the unit includes means for displaying one or more operating parameters of the air conditioning apparatus.

12. A unit as claimed in any one of claims 8 to 11, further including means for providing an alarm whenever an operating parameter attains a predetermined value.

13. Air conditioning apparatus for a building, comprising a first liquid circuit including refrigerating means for cooling liquid in the circuit and a heat exchanger for cooling air within the building, a second liquid circuit having liquid cooling means, including an air cooling tower and filter means, including a filter element as claimed in any one of claims 1 to 7, for cleaning the liquid in or from the second liquid circuit, the liquid cooling means being external to the building and control means for connecting the second circuit across the heat exchanger either in a first mode in which the refrigerating means is simultaneously switched off and isolated from the heat exchanger or in a second mode in which a mixture of liquid from the refrigerating means and of the liquid from the liquid cooling means flows through the heat exchanger, the control means being operable in accordance with environmental conditions inside and/or outside the building.

14. Apparatus as claimed in claim 13, further comprising automatic back wash means for washing the filter means and operates an override control for preventing excessive drainage from the first and/or second liquid circuits during back wash.

15. Apparatus as claimed in claim 14, further comprising heat exchange means for exchanging heat between the back wash liquid and liquid circulating in the first or second circuits.

16. Apparatus as claimed in claim 14 or 15 further comprising means for recycling the back wash liquid into the first and second circuits.

17. Apparatus as claimed in any one of claims 13 to 14 wherein the control means are operable in accordance with the enthalpy, or the wet bulb temperature, of the air entering and/or leaving the building or a part thereof.

18. Apparatus as claimed in any one of claims 13 to 15 further comprising means for operating the refrigerating means whereby, in conditions of partial load, the temperature of the liquid in the first circuit is varied inversely with respect to the external environmental temperature.

19. Apparatus as claimed in any one of claims 13 to 18 wherein the filter is in a modular unit as claimed in claims 8 to 12.

20. Air conditioning apparatus for a building comprising a first liquid circuit including refrigerating means for cooling liquid in the circuit and a heat exchanger for cooling air within the building, a second circuit for cooling the refrigerating means having a cooling tower

external to the building and including filter means, including a filter element as claimed in any one of claims 1 to 7, downstream of the tower and a third liquid circuit for selectively connecting the second circuit across the heat exchanger in accordance with environmental conditions inside and/or outside the building, a part thereof, or a room therein.

21. Air conditioning apparatus for a building, comprising a first liquid circuit including refrigerating means for cooling liquid in the circuit and a heat exchanger for cooling air within the building, a second liquid circuit including a filter element as claimed in any one of claims 1 to 7 for cooling the refrigerator means and having liquid cooling, external to the building, and a third liquid circuit for selectively connecting the second circuit across the heat exchanger and control means for controlling the operation of the refrigerating means and/or the connection of the second circuit across the heat exchanger in accordance with the enthalpy or wet bulb temperature of air entering and/or leaving the building or a part thereof or inside or outside a room in the building or such that the temperature of the liquid in the second circuit varies inversely with the external environmental temperature.

22. Air conditioning apparatus for a building comprising a first liquid circuit including refrigerating means for cooling liquid in the circuit and a heat

exchanger for cooling air within the building, a second liquid circuit for cooling the refrigerating means having a cooling tower external to the building, a third liquid circuit for selectively connecting the second circuit across the heat exchanger, filter means, including a filter element as claimed in any one of claims 1 to 7 downstream of the tower in the second or third circuits and anti-drain means for automatically maintaining a predetermined quantity of liquid in one or more of the liquid circuits.

23. Apparatus as claimed in claim 22, wherein the filter means has an automatic back wash facility, and wherein the anti-drain means comprises means for overriding the back wash facility.

24. A filter including an inlet, an outlet, filter elements as claimed in any one of claims 1 to 7, for filtering fluid flowing between the inlet and the outlet, a back wash discharge outlet, and a rotatable back wash pipe for connecting, one at a time, the inlets of the filter elements to the discharge outlet, wherein the back wash pipe is free to move away from the filter elements and the discharge pipe to allow maintenance access.

25. A filter as claimed in claim 24, wherein the backwash pipe is mounted on a hinged door.

26. A filter as claimed in claim 25 further comprising a motor for rotating the back wash pipe, the motor being mounted on the door and a rotary coupling

extending between the motor and the back wash pipe.

27. A filter including an inlet, an outlet, filter elements, as claimed in any one of claims 1 to 7 for filtering fluid flowing between the inlet and the outlet, and means for swirling the fluid flow so that it is generally evenly distributed along the length of the filter element.

28. A filter as claimed in claim 27, wherein the swirling means comprises a frusto-conical body having an annular flange extending around the periphery of its larger end, the flange having a plurality of openings formed therein and a swirl-inducing guide element for each opening.

29, A filter comprising an inlet and an outlet, filter elements, as claimed in any one of claims 1 to 7, disposed in inner and outer arrays for filtering fluid flowing from the inlet to the outlet, means for reversing the flow through one element to clean the element whilst maintaining normal filtering flow through the outer elements, the flow reversing means operating successively on elements in one array and then on elements in the other array.

30. A filter as claimed in claim 29 wherein the flow reversing means may comprise a pair of relatively rotatable pipes arranged to sweep, successively, the inlet ends of the elements in their respective array.

31. A filter, including a filter element as claimed in claims 1 to 7 substantially as hereinbefore described with reference to the accompanying drawings.